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ABSTRACT

This document presents 1994 results of the Assessment of Achievement Programme, established by the Scottish Office Education and Industry Department to monitor performance of pupils in Scottish schools in particular areas of the curriculum. Samples of pupils were selected to be representative of pupils in all mainstream schools, whether education authority, grant-aided or independent. Over 9,000 pupils completed assessments. The written survey involved 2,633 students at P4, 2,563 at P7, and 4,007 at S2. About half took part in the survey of performances on practical mathematics. This survey provided information on current performance of written and practical mathematics at Primary 4, Primary 7, and Secondary 2, with detailed analyses within the categories of information handling, number, money and measurement, shape, position and movement, and problem solving; comparisons between stages on written and practical tasks; comparison of the performance of boys and girls at each stage; comparison of performance in 1994 with findings from the 1991 and 1988 surveys; and performance in relation to levels of Scottish National Guidelines: Mathematics 5-14. Each school participating in the survey completed a questionnaire that included questions on time spent on mathematics, resources and support for teaching, quantity of mathematics homework, computer and calculator usage, etc. (MKR)

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ASSESSMENT OF ACHIEVEMENT PROGRAMME

1994

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Assessment of Achievement Programme

Fourth Survey of Mathematics

1994

THE SCOTTISH OFFICE
Education and Industry Department

This summary report presents the main findings of the fourth AAP survey of mathematics and highlights teaching issues.

The full report of the survey (including technical and statistical details) is available from the Department of Mathematics, Science and Technological Education, Faculty of Education (Jordanhill), University of Strathclyde, 76 Southbrae Drive, Glasgow G13 1PP.

Information about AAP surveys is also contained in the following publications:

> *Feedback* — a resource for teachers with information about pupils' performance at P4, P7 and S2 and examples of assessment tasks.
>
> *Noticeboard* — the AAP newsletter which presents information about work in progress, results from the latest surveys and general news about the programme.

For further details of these publications, contact the RIU Dissemination Officer, SCRE, 15 St John Street, Edinburgh EH8 8JR. Fax: 0131 556 9454.

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1 Introduction

The Assessment of Achievement Programme (AAP) was established by The Scottish Office Education and Industry Department (SOEID) in 1981 to monitor the performance of pupils in Scottish schools in particular areas of the curriculum. Since 1983, there have been regular surveys in three core curricular areas – English language, mathematics and science. The main objectives of the AAP are to describe national levels of attainment and to provide evidence about changes in these levels over time. The surveys are intended to inform the SOEID, education authorities, teachers and other interested parties about the achievement of pupils and to indicate ways of improving teaching and learning.

The 1994 AAP Mathematics survey

This survey was directed by Dr I J Robertson, Lecturer (Research) and Mr R C Meechan, Head of the Department of Mathematics, Science and Technological Education in the Faculty of Education (Jordanhill), University of Strathclyde, Glasgow. They also directed the third survey of mathematics, carried out in 1991.

The responsibility for drawing samples of schools and pupils within schools lies with the AAP Central Support Unit (CSU) established at the Scottish Council for Research in Education (SCRE) in Edinburgh. They advise on technical matters and liaise with participating schools, distribute materials for the written assessments and carry out the statistical analysis of survey data.

The AAP Mathematics survey took place in May/June 1994. It has provided information on:

- current performance of written and practical mathematics at Primary 4 (P4), Primary 7 (P7) and Secondary 2 (S2), with detailed analyses within the categories of *Information Handling; Number, Money and Measurement; Shape, Position and Movement* and *Problem Solving*;
- comparisons between stages on written and practical tasks;
- comparison of the performances of boys and girls at each stage;
- comparison of performance in 1994 with findings from the 1991 and 1988 surveys;
- performance in relation to levels of *National Guidelines : Mathematics 5–14*.

Sampling

Samples of pupils at P4, P7 and S2 stages were selected to be representative of pupils in all mainstream schools, whether education authority, grant-aided or independent. Over 9000 pupils completed assessments. The written survey involved 2633 pupils at P4, 2563 at P7 and 4007 at S2. About half at each stage took part in the survey of performance on practical mathematics tasks including practical problem solving. Equal numbers of boys and girls were chosen for every aspect of the survey.

Assessment

Assessment was based on the curriculum defined in *National Guidelines Mathematics 5–14, Information Handling, Number, Money and Measurement* and *Shape, Position and Movement* have been adopted as the main AAP reporting categories. Sub-categories can be seen to be closely related to strands of 5–14 guidelines. Figure 1 overleaf illustrates the assessment framework used in the survey.

To assess the learning outcome of *Number, Money and Measurement*, the sub-categories of *Number Concepts, Basic Processes* and *Applications* have been used. Each of these sub-categories has been further divided, matching (but not identical to) strands of 5–14 guidelines.

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Number Concepts includes 5–14 strands of 'add and subtract', 'multiply and divide' 'range and type of numbers', 'round numbers', 'patterns and sequences', and 'functions and equations'.

For purposes of assessment, it was considered important to distinguish between carrying out routine algorithms and applying them in different contexts. The AAP survey assessed these as *Basic Processes* and *Applications*, respectively.

An innovative aspect of the 1994 survey was the development, piloting and use of extended written and practical tasks to assess *Problem Solving* activities.

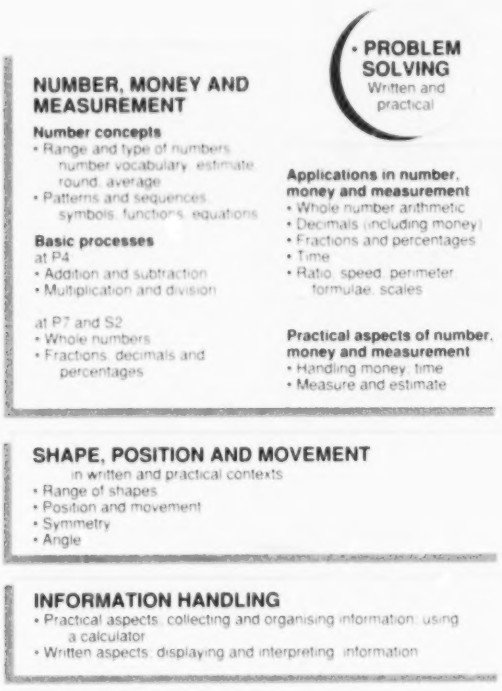
• PROBLEM SOLVING
Written and practical
NUMBER, MONEY AND MEASUREMENT
Number concepts
• Range and type of numbers: number vocabulary: estimate: round: average
• Patterns and sequences: symbols: functions: equations
Basic processes
at P4
• Addition and subtraction
• Multiplication and division
at P7 and S2
• Whole numbers
• Fractions, decimals and percentages
Applications in number, money and measurement
• Whole number arithmetic
• Decimals (including money)
• Fractions and percentages
• Time
• Ratio, speed, perimeter, formulae, scales
Practical aspects of number, money and measurement
• Handling money, time
• Measure and estimate
SHAPE, POSITION AND MOVEMENT
in written and practical contexts
• Range of shapes
• Position and movement
• Symmetry
• Angle
INFORMATION HANDLING
• Practical aspects: collecting and organising information; using a calculator
• Written aspects: displaying and interpreting information

Figure 1: Assessment Framework

Survey materials

Altogether 37 different pupil assessment booklets were used in the written survey. (There were 10 booklets at P4, 12 booklets at P7 and 15 booklets at S2.) This was necessary to ensure the greatest possible coverage of the wide mathematics curriculum currently being taught in Scottish schools. Teachers in the schools sampled supervise the written assessments but do not provide pupils with any help with the mathematics. Each pupil attempted two booklets. One booklet presented mathematics within simple, familiar contextual themes. The other provided a more traditional format, ie one in which the items were not set in context.

The practical survey, which was supervised by trained assessors, covered information handling, handling money, measurement, estimation and problem solving. The use of calculators was assessed with a small number of items in the practical survey.

Attainment targets and levels defined in *Mathematics 5–14* guidelines provided a guide to the selection of tasks for the 1994 survey. For comparisons of performance over time, approximately two thirds of the written tasks from 1991 were used in the 1994 survey.

Practising teachers were contracted to write new materials for the 1994 survey. Care was taken to establish an appropriate balance and progression of questions in written papers and to ensure that each pupil would be able to complete some tasks. However, in order to assess what the most able pupils were able to do, it was necessary to include some tasks which it was likely that only a small number of pupils at a particular stage could complete successfully.

Evaluating and reporting performance

Altogether, over 1000 written tasks and over 100 practical tasks were used in the 1994 survey. At P4, approximately 500 pupils attempted each written task and at P7, approximately 400 pupils attempted each of a larger number of tasks. At S2, over 500 pupils provided data for each task.

Statements about performance of pupils are made for each of the sub-categories identified in the assessment framework. Almost every sub-category provided information on at least 20 tasks and most sub-categories were considerably larger. In general, only findings which can be demonstrated to be statistically significant (at the 1% or 5% levels of confidence) are reported.

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2 Performance in Relation to 5-14

In the 5–14 programme the following broad criteria indicate the approximate stage of schooling at which pupils can be expected to attain the various levels of performance.

Level A — should be attainable in the course of P1–P3 by almost all pupils.

Level B — should be attainable by some pupils in P3 or earlier, but certainly by most in P4.

Level C — should be attainable in the course of P4–P6 by most pupils.

Level D — should be attainable by some pupils in P5–P6 or even earlier, but certainly by most in P7.

Level E — should be attainable by some pupils in P7–S1, but certainly by most in S2.

To make the findings relevant to teachers, the project team has matched tasks to levels A - E and 'beyond level E' (E+) as these are defined in attainment targets of *National Guidelines: Mathematics 5–14*.

An independent consultant appointed by SOEID re-examined the match made of tasks to levels in the 1991 survey. Members of the 1994 AAP Mathematics Project Committee advised on the match of all new tasks to 5–14 levels. The Committee also approved the overall balance of items by level which was achieved in the survey.

Figure 2 below shows performance in relation to the 5-14 levels for P4, P7 and S2. The data relates to the written tasks.

At P4, the mean score on level B tasks was 64% and many level C and D tasks were completed successfully. At P7, the mean score on level D tasks was 58% and many tasks at level E and beyond were completed successfully. At S2, the mean score on level E tasks was 47% and many tasks beyond level E were completed successfully.

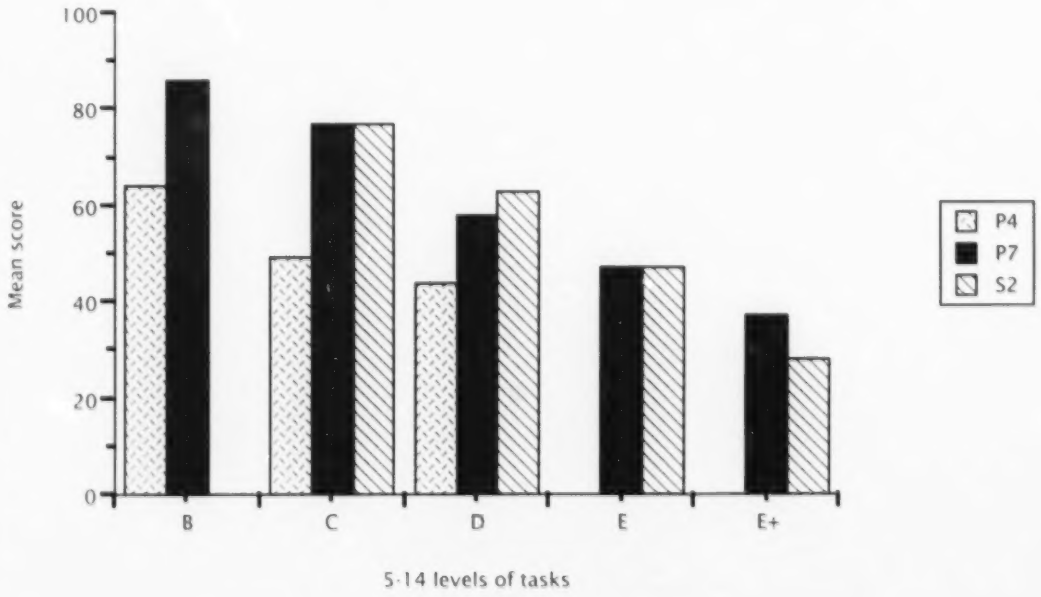

Figure 2: Performance in relation to 5–14 levels (mean scores)

3 Information Handling

The categories assessed in the written papers correspond closely to the strands *Display and Interpret*. Tasks required the completion and interpretation of various kinds of tables and graphs including bar graphs, pie charts and line graphs. Practical survey tasks assessed *Collect, Organise and Display* as an integrated set of tasks.

Trends and comparisons

Performance in this outcome was high overall. There was no significant difference in performance between 1991 and 1994 at any stage. There was evidence of progression: most P4 and P7 pupils were successful in the tasks common to both stages*, with an increase in performance evident at P7, and there was a significantly higher performance at S2 compared with P7 on tasks which required interpretation or simple calculation.

Primary 4

- All tasks at level B and over 80% of tasks at level C were answered correctly by two thirds of pupils.
- In the practical survey, pupils were better at categorising data by counting and sorting than by using tally tables.
- In the practical survey, 20% of pupils were able to a draw, without an example provided, an acceptably complete bar graph from data which they had collected themselves.

Primary 7

- Performance on level C tasks was high. At level D, just over half the tasks were answered correctly by two thirds of pupils.
- On level D tasks, pupils were good at identifying information in a table or graph but when interpretation or simple calculation was required, performance was much lower.
- In the practical survey, 20% of pupils were able to draw a bar graph with a non-unitary scale which was correct in most details.

Secondary 2

- At S2 about 70% of the tasks at levels D and E were correctly answered by two thirds of pupils.
- In the practical survey, half of the S2 pupils could draw correctly the bar graph in the task which was also given to P7 pupils.

Issues

It is perhaps not surprising that performance was lower on tasks requiring interpretation than on tasks which merely involved direct reading of tables and charts. How can pupils' skills of interpretation best be developed?

*Based on fewer than 10 assessment tasks.

4 Number, Money and Measurement: Number Concepts

This large category covered, at all stages, place value; fraction concepts; conversions between metric units; rounding; completion of simple number sequences and equations. At P7 and S2 concepts included estimation (of answers to calculations), decimal fractions and percentages, negative numbers, understanding of an average value (arithmetic mean) and completion of a function table. At S2, questions were also set on rounding to specified numbers of decimal places and significant figures, understanding of simple inequations and graphs of simple functions.

Trends and comparisons

There were no significant differences at any stage between performances in 1994 and 1991.

Place value (whole number) and completion of simple number sequences and equations were well understood at each stage. Less well done were items involving understanding of place value in decimal numbers (at P7) and more complicated algebraic tasks (S2).

There was a significant increase in performance at P7 compared with P4 on understanding of fractions and rounding. Almost all tasks used at P7 and S2 showed improvement at S2; for half the tasks this was statistically significant. Equivalence of units of length and working with integers which included a negative number showed the greatest improvement.

Primary 4

- 46% of tasks at level B and 20% at level C were answered correctly by two thirds of pupils.
- Place value in two-digit whole numbers was handled well by most pupils, as was marking numbers on a number line.
- Completion of number sequences with simple rules and simple equations were handled well by most pupils.

Primary 7

- 45% of tasks at level D and 37% of tasks at level E were answered correctly by two thirds of pupils.
- Most pupils showed understanding of concepts of place value and rounding with whole numbers. Understanding of place value in decimal numbers was not secure for many pupils.
- Many pupils had difficulty in converting from one metric unit of measure to another.
- Continuation of simple number sequences and solving simple equations were performed correctly by most pupils.

Secondary 2

- 80% of tasks at level C, 45% at level D and 20% at level E were answered correctly by two thirds of pupils.
- Most pupils could round whole and decimal numbers to the nearest 10, 100 and 1000. Performance was significantly lower in rounding of decimal numbers to one decimal place or a specified number of significant figures.
- The understanding of most pupils was secure for common fractions such as halves, thirds, quarters and eighths but less secure for others.
- Most pupils understood only the most familiar whole number percentages.
- Many pupils appeared to consider the only conversion factors between metric units to be 10 and 100.

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- Less than half the pupils showed understanding of an average (arithmetic mean) or could select an appropriate estimate for a calculation.
- Most pupils were able to complete simple numerical sequences.
- Tasks requiring development of formulae or substitution into algebraic expressions had low percentages of pupils answering correctly.
- The solution of simple equations by inspection was achieved by most pupils but success fell sharply for more complex equations.

Issues

How and in what order should the concepts of percentages, common fractions and decimal fractions be introduced?

How can teachers ensure progression in pupils' knowledge and skills in number concepts, while achieving consolidation of previously acquired understanding?

Are S1/S2 pupils, particularly the more able, receiving sufficient teaching of algebra?

Why do pupils at all stages find difficulty in converting between units? How can the problem be overcome?

Are pupils given sufficient practice in estimating answers?

5 Number, Money and Measurement: Basic Processes

Addition and subtraction with whole numbers and multiplication and division with whole numbers were reported as two separate sub-categories at P4. A small number of tasks with decimal numbers and tasks where more than one process was required were also set at P4, for comparisons with P7 and to allow the most able pupils to demonstrate their skills. At P7 and S2, the P4 categories were combined and assessment was of basic processes with whole numbers and basic processes with decimals, fractions and percentages. At all three stages pupils were assessed on their ability to carry out basic processes without the use of a calculator.

Trends and comparisons

At P4, there were significant drops in performance in 1994 compared with 1991 in both addition and subtraction (an average fall of 4.9% over 19 common tasks) and multiplication and division (a fall of 6.5% over 21 items). There were also significant drops in performance at both P7 and S2 on tasks involving fractions, decimals and percentages (a 4.8% drop over 26 tasks at P7 and a fall of 3.5% over 39 items at S2). Performance at S2 on whole number arithmetic also deteriorated (a drop of 4.9% over 27 items).

Most P7 pupils were able to achieve success on whole number tasks which had low levels of success at P4. About half the tasks used at both P7 and S2 had significantly better performances at S2.

Primary 4

- For addition and subtraction (of whole numbers) 70% of pupils were successful on level B tasks and nearly 60% were successful on level C tasks*.
- For multiplication and division, nearly 60% of pupils were successful on level B tasks*, and nearly 40% at level C tasks.

Primary 7

- 23% of tasks at level D were answered correctly by two thirds of pupils.
- Nearly 90% of pupils were successful on whole number tasks at level C and over 70% at level D.
- Nearly half the pupils were successful with level D tasks on decimals, fractions and percentages and over 40% with level E tasks.

Secondary 2

- 43% of tasks at level D and 13% at level E were completed correctly by two thirds of pupils.
- Performance was high for whole number tasks at levels C and D and half the pupils completed level E tasks successfully.
- Most pupils were able to work with decimals, fractions and percentages at level D and just over 40% were successful for level E* tasks.

Issues

Do pupils, particularly in S1/S2, receive sufficient experience of paper-and-pencil work and mental calculation?

Why were there small drops in performance in some sub-categories?

*Based on fewer than 10 assessment tasks.

6 Number, Money and Measurement: Applications

Assessment tasks in this area covered the application of mathematical concepts to realistic situations. Applications with whole numbers requiring addition and subtraction and applications with whole numbers requiring multiplication and division were reported separately at P4. At P7 and S2, strands were combined as applications of whole numbers. Applications of time were a feature of all stages. Other reporting sub-categories used at P7 and S2 were applications of decimals (including money), applications of fractions and percentages and applications concerned with ratio, speed, perimeter, formulae and scale.

Trends and comparisons

At P4 a significant drop in performance was evident between 1991 and 1994 in applications of addition and subtraction (a fall of 4.9% over 19 items) and in 'other processes' (a fall of 5.9% over 23 items). At S2 there was a significant drop in performance between 1991 and 1994 for applications with whole numbers (a fall of 4.9% over 27 items) and applications of decimals (a fall of 3.7% over 22 items).

For whole number tasks there was a significantly higher performance at P7 compared with P4 and almost all performances at S2 were better than those at P7, but not significantly so. Applications of time had significantly higher performances at P7 compared to P4* and tasks in this area with low success rates at P7 showed a significant improvement at S2. All tasks assessing applications of fractions and percentages showed some improvement from P7 to S2*, some significantly so. Many tasks assessing applications of ratio, formulae and scale had significantly higher performances at S2 compared with P7.

Primary 4

- Overall, 67% of tasks set at level B and 16% at level C were answered correctly by two thirds of pupils.
- Performance levels were high in applications of whole number addition and subtraction where key words and phrases made procedures to be adopted clear.
- In applications of multiplication and division, nearly 60% of pupils had success on level B tasks* and over 30% on level C tasks*.
- Performance on applications of time was high on level B tasks with nearly 60% achieving success on level C tasks.

Primary 7

- Overall, two thirds of pupils were successful on 62% of level C tasks and 34% of level D tasks .
- Performance on whole number tasks was good, with over 60% of pupils successful on level C tasks.
- Nearly 50% of pupils were successful on level D decimal tasks.
- For fractions and percentages, performance on level C* and D* tasks was similar with over 60% of pupils achieving success.
- Over 80% of pupils were correct on applications of time at level C and 65% at level D.
- Tasks at level D which involved ratio and scale or applications of formulae were successfully completed by just over 40% of pupils.

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Secondary 2

- 42% of tasks at level D and 10% of tasks at level E were answered correctly by two thirds of pupils.
- Performance on whole number tasks was good, with nearly 70% of pupils successful on level C tasks and 65% on level D tasks.
- Nearly 60% of pupils were successful with applications of decimals in level D tasks and over 40% on level E* tasks.
- Over 60% of pupils were successful with applications of fractions and percentages at level D*. Just under 40% were successful with level E tasks.
- In applications of time, most tasks were at level D and 70% of pupils answered them correctly.
- For applications of ratio, formulae and scale, nearly 70% of pupils answered level D tasks correctly and 40% level E tasks.

Issues

What are the key factors that determine pupils' success in applying their mathematical knowledge and skills in context?

Is it better to introduce concepts and basic processes and then develop skills in applying them, or is it more effective to introduce concepts and processes in context in the first place?

*Based on fewer than 10 assessment tasks.

7 Number, Money and Measurement: Practical Aspects

The assessment of practical skills involved, in the main, short discrete tasks which pupils undertook in circuits. The tasks covered mental calculation, estimating, use of calculators, measuring, handling money and handling time.

Trends and comparisons

Performance on the mental calculation tasks was similar in 1994 and 1991, being high on the three tasks at P7 and good on two of the three at P4. In using calculators, there was no overall difference in performance at any stage between 1991 and 1994. In measurement of length there were significantly better performances at P7 and S2 in 1994 compared with 1991.

Performance levels on six tasks which involved estimation of answers were very low, although S2 performed better than P7 (with means of 8% at P7 and 17% at S2). The performance of P7 pupils in weighing objects was not significantly better than that of pupils in P4. At P7 and S2 most pupils were able to select appropriate estimates for the volumes of various containers. On money handling tasks, P7 pupils performed better on most tasks than P4 pupils.

Primary 4

- 90% of pupils were able to use a calculator to carry out addition, subtraction, multiplication and division tasks correctly if answers did not require rounding. 10% of pupils were able to round their calculation appropriately.
- Most pupils were able to use a two-pan balance to put objects in order of weight but many had difficulty finding the actual weight of an object.
- Most pupils were able to give change from £1 but substantially fewer could give change from £5.
- Most pupils could record two times from a digital 12-hour clock but few could go on to calculate the time interval between them which crossed a change of hour.

Primary 7

- Over 80% of pupils were successful on the money handling tasks.
- One third of pupils could calculate the time interval crossing a change of hour. Over half could convert a 24-hour clock time into am/pm notation.
- 50% of pupils were able to use a calculator and round their calculation appropriately.

Secondary 2

- Over half of the pupils were able to calculate the time interval crossing the change of hour and most could convert a 24-hour clock time into am/pm notation.
- 60% of pupils were able to use a calculator and round their calculation appropriately.

Issues

Do pupils, particularly in secondary schools, receive sufficient experience of practical work?

What contexts would be suitable for S1/S2 practical work?

Would pupils' ability to convert between units be improved by more frequent and regular practice in measuring and estimating?

8 Shape, Position & Movement

The sub-categories of *Range of Shapes, Position and Movement, Symmetry* and *Angle* correspond closely to the strands identified in *National Guidelines: Mathematics 5 – 14*.

Trends and comparisons

Performance in many aspects of this outcome was high overall. At P4, overall performance was significantly worse in 1994 compared with 1991 (a drop of 3.6% over 25 items). The majority of practical tasks showed no differences in performance over this period. There were no significant changes in performance at P7 or S2 between 1991 and 1994.

All tasks common to P4 and P7* showed significant increases in performance at P7 and about half the tasks common to P7 and S2 showed a significant increase in performance at S2.

In the practical survey, several tasks with 3D solid shapes were done as successfully by P4 pupils as by P7 pupils. Half the P7 and S2 pupils could identify the number of ways in which a rectangular bankcard could fit the slot in a cash machine. 15% at P7 and one third at S2 could determine what the answer would be for a square card.

Primary 4

- Overall, 53% of tasks at level B and 27% of tasks at level C were answered correctly by two thirds of pupils.
- Most pupils could recognise or name squares, triangles, hexagons, circles, cubes and pyramids.
- On level B tasks on position and movement, most pupils could use map-type co-ordinates. Fewer were successful with compass directions.
- 80% of pupils were able to complete shapes about a vertical or horizontal axis of symmetry (levels A and B tasks) and many were successful on level C tasks.
- Many level C tasks, including recognition of right angles, were achieved by just under half the pupils.

Primary 7

- Overall, 69% of tasks at level C and 55% at level D were completed correctly by two thirds of pupils.
- High levels of performance were shown for level C tasks* on range of shapes, and most pupils achieved success on level D tasks. These included naming 2D shapes, recognition of 3D shapes from their 2D representations and also the net of a cube.
- Just over half the pupils could determine the radius of a circle given the diameter and vice versa.
- Reading co-ordinates and plotting points, using map-type and Cartesian co-ordinates (1st quadrant only), was done successfully by most pupils. The use of 8-point compass notation was less successful.
- Completing symmetrical shapes was well done by most pupils. Identification of the axes of symmetry of squares and rhombuses was also well done but only half were correct with a rectangle (the diagonal being identified as a line of symmetry).
- Most pupils were able to identify obtuse angles and angles of 45°, 90°, 180° and 270°.
- Determining the sizes of other angles, eg angles associated with parallel lines, was achieved by few pupils.

Secondary 2

- Overall, 46% of tasks at level D and 18% of tasks at level E were answered correctly by two thirds of pupils.

- Recognition of simple 2D shapes was achieved by less than two thirds of pupils and using their properties by even less.
- Recognition of simple 3D shapes from their 2D representations was well done by most pupils. Successful drawing of nets of solids depended on the solid involved.
- About 60% of pupils were able to determine the radius of a circle when given the diameter (and vice versa).
- Most pupils were able to carry out tasks requiring understanding of an 8-point compass rose.
- Most pupils could use Cartesian co-ordinates in the first quadrant but only one third could plot points correctly in the other three quadrants.
- Most pupils could draw or recognise lines of symmetry provided that the axis was vertical or horizontal, but many had difficulties with diagonal axes.
- Lines of symmetry were correctly identified for squares and rhombuses, but just over half the pupils were correct for a rectangle.
- Only one third of S2 pupils could work with rotational symmetry.
- Knowledge about vertically opposite angles was demonstrated by under two thirds of pupils, of angles associated with parallel lines by just over half the pupils and about the angles of a triangle by just over one third of pupils.
- In the practical survey, slightly more than half the S2 pupils could identify the numbers of faces, vertices and edges of cubes, prisms and pyramids.
- In the practical survey, measuring and estimating angles in the context of using a street map were achieved by just under two thirds of the S2 sample.

Issues

Pupil performance on many aspects of Shape, Position and Movement appears to increase between P4 and P7. Progression from P7 to S2 is less clear. How can programmes of work and teaching approaches be adjusted to improve matters in S1/S2?

*Based on fewer than 10 assessment tasks.

9 Problem Solving

Considerable emphasis is laid on the inclusion of *Problem Solving* at all stages of the current Scottish mathematics curriculum and in this survey pupils' achievement in *Problem Solving* has been assessed in three different ways.

1) Short response tasks, carried forward from the 1991 survey, in the written papers at all three stages;

2) Extended response tasks in the written papers at P7 and S2;

3) Extended problems in the practical survey at all three stages. These problems were presented in a one-to-one situation by a trained assessor who recorded each pupil's response, at specified stages, through the course of the task, and with an analysis of the strategies employed. Appropriate prompts were given to the pupil when necessary.

It should be borne in mind that the AAP problem solving tasks were done by individuals, whereas in classrooms problem solving is often a group activity.

Trends and comparisons

There was no significant difference shown in overall performances in most of the short response tasks carried forward from 1991 to 1994. There was an overall increase in performance between P4 and P7 on the three common tasks and between P7 and S2 on three of the four tasks which were common to these two stages.

In the written survey

- Pupils appeared to prefer to use a diagrammatic approach to other strategies only if the diagram was fairly simple. As the complexity increased, pupils tended to revert to written descriptions.
- Pupils did not, in general, check that all possibilities had been covered.
- Pupils appeared to prefer to use a random approach rather than a systematic procedure. When a systematic approach was adopted, the strategy was usually 'trial and improvement'.
- In a problem which involved selecting and timetabling leisure activities from lists, subject to stated constraints, 61% of P7 pupils and 65% of S2 pupils were able to produce an acceptable answer.

In the practical survey

- Pupils often stated that they understood the task despite evidence, in later stages of the problem, of a lack of initial comprehension.
- There was reluctance to handle equipment and materials despite clear encouragement.
- In a problem which required pupils to make a model of a box and check whether an object would fit inside it, 19% of P7 pupils were able to work through the task completely satisfactorily. 50% were able to complete at least one stage satisfactorily. The corresponding percentages for S2 were 39% and 65%.

Issues

Are pupils presented with a sufficiently wide range of problems to solve?

How can teachers best introduce pupils to problem solving strategies?

Would more practical experience and group discussion help pupils to improve their problem solving skills?

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10 Information from Schools

Each school taking part in the AAP mathematics survey was asked to complete a questionnaire. This included questions on curriculum; resources and support for teaching; organisation of teaching; extra support for pupils; use of calculators and computers and primary/secondary liaison.

Time spent on mathematics

- 40% of primary schools spent between 2 and 3 hours and a further 40% spent between 3 and 4 hours on mathematics at both P4 and P7 stages during the week prior to the survey.
- In 98% of secondary schools, S2 was reported as spending at least 3 hours per week on mathematics. For 60% of schools the time spent was at least 3½ hours and for 12% of schools it was between 4 hours and 4 hours 35 minutes.

Resources

- As in 1991, 90% of primary schools use *SPMG/Heinemann* as their main resource.
- In secondary schools *SMP* was used 'frequently' at S2 in 58% of schools – a similar finding to 1991. The 'frequent' use of *Maths in Action* has increased from 25% of schools in 1991 to 37% in 1994.
- In P7, one third of primary schools introduce a resource from the early stages of secondary school. A quarter of the sample of primary schools reported doing this in 1991.

Mathematics homework

- Two thirds of primary schools and 97% of secondary schools had set mathematics homework during the week prior to the survey.
- 40% of primary schools and over 50% of secondary schools reported setting 15–30 minutes of homework per week. Most of the other schools which had set homework had set 40–60 minutes.

Practical mathematics

- Practical mathematics activities are much more common in primary than in secondary schools.

Computers and calculators

- Computers were used more frequently in mathematics in primary than in secondary schools (over 70% of primary compared with 55% of secondary).
- Computers were used most frequently by groups of pupils rather than individuals and there was a wide variation on the time reported as being spent on these activities.
- Although the most common use of computers was for reinforcement of learning, over 50% of schools recorded their use in investigations and problem solving.
- One quarter of primary schools introduced the calculator in P1, a further half at P2 and the remainder by P4.

Learning support

- Specialised learning support teachers were available in mathematics in 60% of secondary and 25% of primary schools in the week before the survey.

Primary/secondary liaison

- Almost all schools reported arrangements in place. In the main, these involved transfer of information and visits by secondary mathematics staff to primary schools.

11 Analysis of Performance

The performance of pupils in mathematics in 1994 can be assessed a) in relation to the 5–14 levels and b) in relation to common assessment tasks from the previous survey in 1991.

Overall performance in relation to the 5-14 guidelines was reasonable at P4, but poorer at P7 and much poorer at S2.

- At P4, where 'most pupils' should attain level B, the mean score on tasks rated as level B was 64%.
- At P7, where 'most pupils' should attain level D, the mean score on tasks rated as level D was 58%.
- At S2, where 'most pupils' should attain level E, the mean score on tasks rated as level E was 47%.

It should be noted that the formal testing context in which AAP assessments are carried out is likely to produce poorer performance than would normally be found in pupils' school work.

Most of the drops in performance between 1991 and 1994 were in basic processes of mathematics and their application. Mean scores on common tasks fell between 1991 and 1994 by 5% in 6 of the 11 aspects assessed at P4, by 5% in 1 of the 12 aspects assessed at P7 and by 4% in 4 of the 14 aspects assessed at S2. There were no categories in which significant gains in performance were found in 1994 and, except at P4, performance in most categories remained the same.

The comparisons above provide a basis for identifying strengths and weaknesses in pupils' performance. The picture is summarised in Figures 3 — 5 below.

There was little difference in the performance of girls and boys in the majority of tasks. At P4 girls did better than boys in a minority of tasks, at P7 boys did better than girls and at S2 the performance of boys and girls was equally good.

Figure 3: P4 — performance on aspects of mathematics

	Mean score on all tasks (%)	Mean score on level B tasks (%)	Comparison with 1991
INFORMATION HANDLING			
Display and interpret	77	80	No change
NUMBER CONCEPTS			
Range and type of number, number vocabulary	53	56	No change
Patterns and sequences	65	68	No change
BASIC PROCESSES			
Addition and subtraction	62	70	Better in 1991
Multiplication and division	42	59	Better in 1991
APPLICATIONS			
Addition and subtraction	62	59	Better in 1991
Multiplication and division	40	56	No change
Time	64	77	No change
Other	42	54	Better in 1991
SHAPE, POSITION & MOVEMENT			
Range of shapes, symmetry	69	79	Better in 1991
Position and movement, angle	51	56	Better in 1991

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Figure 4: P7 — performance on aspects of mathematics

	Mean score on all tasks (%)	Mean score on level D tasks (%)	Comparison with 1991
INFORMATION HANDLING			
Display and interpret	77	64	No change
NUMBER CONCEPTS			
Range and type of number, number vocabulary, estimate, round and average	61	59	No change
Patterns and sequences, symbols, functions and equations	59	70	No change
BASIC PROCESSES			
Whole number arithmetic	79	72	No change
Decimals, fractions and percentages	43	49	Better in 1991
APPLICATIONS			
Whole number arithmetic	65	N/A	No change
Decimals	50	47	No change
Fractions and percentages	55	62	No change
Time	74	65	No change
Ratio, formulae and scale	44	41	No change
SHAPE, POSITION & MOVEMENT			
Range of shapes, symmetry	63	65	No change
Position and movement, angle	67	70	No change

Figure 5: S2 — performance on aspects of mathematics

	Mean score on all tasks (%)	Mean score on level E tasks (%)	Comparison with 1991
INFORMATION HANDLING			
Display and interpret	76	69	No change
NUMBER CONCEPTS			
Range and type of number, number vocabulary, estimate, round and average	52	46	No change
Patterns and sequences, symbols, functions and equations	33	46	No change
BASIC PROCESSES			
Whole number arithmetic	71	50	Better in 1991
Decimals, fractions and percentages	50	44	Better in 1991
APPLICATIONS			
Whole number arithmetic	66	N/A	Better in 1991
Decimals	55	41	Better in 1991
Fractions and percentages	44	38	No change
Time	65	N/A	No change
Ratio, formulae and scale	43	41	No change
SHAPE, POSITION & MOVEMENT			
Range of shapes	54	46	No change
Symmetry	57	49	No change
Position and movement	58	47	No change
Angle	53	53	No change